MANAGING RED PINE *for* POLES *in* LOWER MICHIGAN

By Paul C. Guilkey

STATION PAPER NO. 57
JANUARY, 1958

LAKE STATES FOREST EXPERIMENT STATION
M. B. DICKERMAN, DIRECTOR

FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

Cover picture: A 37-year-old red pine plantation planted at a 5x5-foot spacing. Basal area stocking is about 190 square feet per acre. The stand has a high proportion of trees with straight boles, a low number of branches per whorl, and small branch diameters. Since about two-thirds of the trees in this stand meet the specifications of potential pole trees, the majority of the individuals not meeting these specifications can be removed in the first thinning.

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IN LOWER MICHIGAN

by

Paul C. Guilkey[1/]

Introduction

One of the prerequisites for the successful management of red pine is a ready market for a variety of high value products. One such product with a potentially large and stable market is the red pine utility pole. While quality sawlogs may continue to be the most important primary product, the unit value of utility poles is higher than that of sawlogs and is second only to piling. In recent years both red pine and jack pine have been used for utility poles elsewhere in the Lake States but poles of these species have not been produced or used in Lower Michigan. Some locally produced white-cedar is used, but the bulk of poles are pine imported from the South.

The local demand for utility poles is increasing each year. About 250,000 poles were used in 1954 to maintain and extend existing lines in Lower Michigan. This demand is expected to increase at the rate of about 3 percent annually. Because of this potential market and the large acreage of planted red pine now nearing merchantability, both utility companies and forest land managers have expressed an interest in the potential red pine pole supply and the timber management practices best suited to utility pole production.

To supply this information, the Lake States Forest Experiment Station, in cooperation with the Michigan Department of Conservation, made a study in 1955 of the red pine stands in Lower Michigan. The results of the study, presented in this report, cover the present and potential pole supply, the stand conditions that favor production of trees acceptable as poles, and management recommendations.

1/ Forester at the Lower Peninsula Forest Research Center, which is maintained at East Lansing, Mich., by the Lake States Forest Experiment Station in cooperation with Michigan State University. The Station, in turn, is maintained at St. Paul 1, Minn., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Minnesota.

Method of Study

The study was planned so that the most efficient use could be made of up-to-date area statistics on the red pine type already available from the Forest Survey.

Over 100 red pine stands throughout the Lower Peninsula were located and examined by the field crew. About 60 stands were sampled and classified by Forest Survey stand size and stocking class (Appendix A). Temporary 1/5-acre plots were located at random in each red pine stand sampled. All trees 5.0 inches and larger in diameter at breast height (d.b.h.) were tallied by species, d.b.h., and merchantable height. All red pine trees 5.0 to 9.5 inches in diameter were classified as either potential poles or as rejects and those 9.5 inches and larger, usable as class 4, 5, 6, or 7 poles according to the American Standard Wood Pole Specifications, (Appendix B), were tallied by class and pole length or as rejects. The causes of rejection were recorded--crook, sweep, limbs, and other.

The probable effect of current management practices[2/] on the present and potential pole supply was assessed by making cutting recommendations on each sample plot for thinnings, improvement cuttings, and intermediate harvest cuttings. This was accomplished by designating each tree either "cut" or "leave". In addition, not more than 25 "leave" trees per 1/5-acre plot were further designated as crop trees. These crop trees were considered to be those that would make up the final harvest cut of sawtimber. Such trees are often the largest and fastest growing trees in the stand. Wolf trees, poorly formed trees, and trees of undesirable species were not considered crop trees regardless of size or growth rate. Nearly all of the crop trees were red pine, although an occasional well-formed, fast-growing white pine or red oak was accepted. Both plantations and natural stands of red pine were sampled as they were encountered on the pole survey.

The Red Pine Type in Lower Michigan

Red pine was once a major component of the Lower Michigan pineries. It occurred in pure stands or in mixture with jack pine on the sandy or gravelly soils and in mixture with white pine and hardwoods on the better soils. In the 1800's both logging and land clearing were all too often accompanied by unchecked fires that nearly wiped out the

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2/ Eyre, F. H., and Zehngraff, Paul. Red pine management in Minnesota. U. S. Dept. Agr. Cir. 778, 70 pp., illus. 1948.

once prominent pine forests. The combination of fire protection and forest planting beginning in the early 1900's first slowed and finally reversed the decline in red pine acreage. The lowest ebb in the area of red pine in Lower Michigan was probably reached in the 1920's.

Since the first Forest Survey in 1936 the estimated area of the red pine type, by Survey standards, has increased rapidly. Nearly all of this increase is the direct result of forest planting by both public and private agencies. The area in the sawtimber and poletimber stand size classes increased from 16,000 acres in 1936 to 60,000 acres in 1955 (table 1). A survey now in progress undoubtedly will show a large increase in the restocking size class also.

Table 1.--Area of red pine type in Lower Michigan, 1936 and 1955 1/
(acres)

Size class	In 1936	In 1956			
		Total	Good stocking	Medium stocking	Poor stocking
Large sawtimber	3,000	3,900	500	1,000	2,400
Small sawtimber	6,000	20,900	400	8,300	12,200
Poletimber	7,000	35,300	500	8,700	26,100
Restocking	17,000	(2/)	-	-	-

1/ Unpublished data of the Forest Survey in files of the Lake States Forest Experiment Station.
2/ New Survey in progress.

While the apparent increase is impressive, it falls short of the known area planted to red pine. Many of the early plantations failed because of unfavorable sites, drought, and lack of release. Thousands of acres planted under thin stands of hardwoods are classed as aspen, oak, or other hardwoods by the Forest Survey because the pine appears only in the understory. As these stands are released by cutting, herbicides, and other means, the area classed as red pine will increase.

All of the existing large sawtimber and many of the small sawtimber stands are natural, either remnants of original pine forest or second-growth that followed the early cuttings. About one-half of the pole-timber and nearly all of the restocking areas are in plantations. Improved management will undoubtedly result in better stocking than now exists in the older stands. As planting continues and as the

plantations reach merchantability, the red pine type will continue to grow in value and importance in Lower Michigan.

The Present Pole Supply

About 215,000 red pine trees in the red pine poletimber and sawtimber stands in Lower Michigan are usable as class 4, 5, 6, and 7 poles (table 2). Of this total, 2 percent are in the large sawtimber stands, 97 percent in the small sawtimber stands, and the remaining 1 percent in the poletimber stands.

Table 2.--Number of red pine trees usable as poles in the red pine sawtimber and poletimber stands in Lower Michigan, 1955

Stand size class	Stocking class: All	Good	Medium	Poor
Large sawtimber	5,000	3,000	2,000	-
Small sawtimber	208,500	14,600	157,200	36,700
Poletimber	1,500	1,500	-	-
Total	215,000	19,100	159,200	36,700

Only a few pole trees will be available for cutting during 1955 to 1965. Although there are 5,000 trees now usable as poles in the large sawtimber stands, it is unlikely that many of these stands will be cut since many of them are being held for their recreational and scenic value. In those large sawtimber stands that will be cut, the number of pole trees per acre is low; these trees will probably be cut for saw-logs or for piling.

The red pine small sawtimber stands are as yet too young for either regeneration or final harvest cuts. Most of the pole trees should be held for later intermediate harvest cuts or for the final crop (table 3), but stands now overstocked with pole trees should yield about 900 poles per year from intermediate harvest cuts during the next 10 years.

Table 3.--Growing stock classification of pole trees in small sawtimber stands in Lower Michigan, 1955

(number of trees)

Stocking class	Total	To be cut		Crop trees
		1955-1965	After 1965	
Good	14,600	490	2,630	11,480
Medium	157,200	8,280	20,680	128,240
Poor	36,700	-	-	36,700
All densities	208,500	8,770	23,310	176,420

The well-stocked red pine small sawtimber stands average 34 pole trees per acre and the medium-stocked small sawtimber stands average 19 per acre. Since most of these are crop trees, the number that will be marked for the next thinning seldom exceeds five trees per acre, and only averages about one tree per acre. In the absence of nearby treating plants, it is unlikely that many will be cut and used for poles.

None of the trees now suitable for red pine poles in the poletimber stands should be cut during the next 10 years. The pole trees are among the best and largest trees in these stands and will form a major part of the final crop.

The Potential Pole Supply

The potential supply of red pine poles in trees now 5.0 to 9.5 inches in diameter in the small sawtimber and poletimber stands is over 7 times larger than the present supply (table 4 on next page).

These potential poles are trees free from crook, excessive sweep, or other defects, and will be usable as poles if left to grow to pole size. Any tree with limb whorls in the lower live crown that will have an aggregate knot diameter of 6 inches or more when the tree reaches pole size is also excluded. Since the potential pole trees are straight and thin limbed, very few of them will be marked for cutting during the next 10 years; however some potential pole trees must be cut to provide adequate growing space for the residual stand.

Table 4.--Number of potential poles in the red pine sawtimber and poletimber stands in Lower Michigan, 1955
(number of trees)

Stand size class	Stocking classes: All	Good	Medium	Poor
Large sawtimber	0	0	0	0
Small sawtimber	786,500	14,600	380,600	391,300
Poletimber	806,100	75,700	600,200	130,200
Total	1,592,600	90,300	980,800	521,500

The annual allowable cut of red pine poles will increase as the average age of the present red pine stands increases. The gain in the next 20 years will come from the pole and potential pole trees now standing in the medium- to well-stocked small sawtimber and poletimber stands. Following this period, the number of pole trees will increase rapidly as the large area of medium- to well-stocked young red pine plantations reaches small sawtimber size. The possible harvest of red pine poles from these stands will be greatly influenced by the number and kind of trees removed in early thinnings.

Factors Affecting Acceptability of Trees as Poles

The criteria for pole selection are straightness and knot size. Trees are rejected for limbiness, which is closely related to stand density, and for crook or sweep. Each of these factors is discussed below.

Stand Density and Limbiness

The number of trees per acre suitable for poles increases as stand density increases (table 5). The present large sawtimber stands are too old, too limited in area, and too open to produce many pole trees. Even the best stands average only six pole trees per acre.

When the data are regrouped according to the basal area per acre of all trees 5.0 inches and larger, the number of poles and potential poles per acre for small sawtimber and poletimber stands shows a definite increase with an increase in stocking (fig. 1).

Table 5.--Number of pole and potential pole trees per acre by stand size and stocking class in Lower Michigan, 1955

Stand size and stocking class	All species	Red pine only			
		All red pine	Pole trees	Potential pole trees	Rejects
Small sawtimber					
Good stocking	242	174	34	34	106
Medium stocking	237	170	19	46	105
Poor stocking	131	111	3	32	76
Poletimber					
Good stocking	437	310	3	147	160
Medium stocking	226	161	-	69	92
Poor stocking	154	93	-	5	88

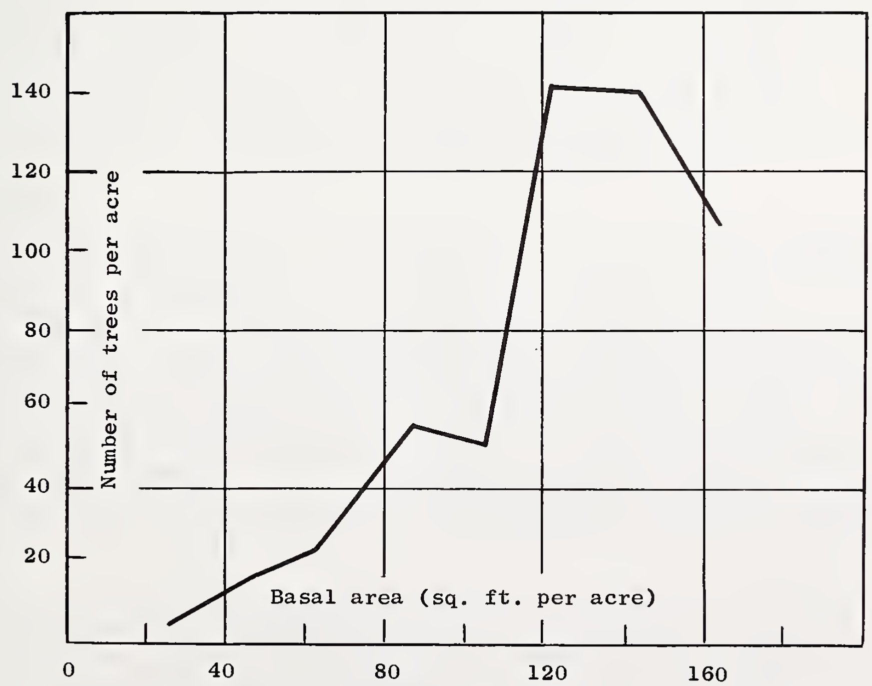

Figure 1.--Number of pole and potential pole trees per acre by stocking level.

As stand density increases the proportion of trees usable as poles increases, showing the effect of stand density on the quality of the trees. This is demonstrated by plotting the proportion of all red pine classed as poles or potential poles over basal area (fig. 2).

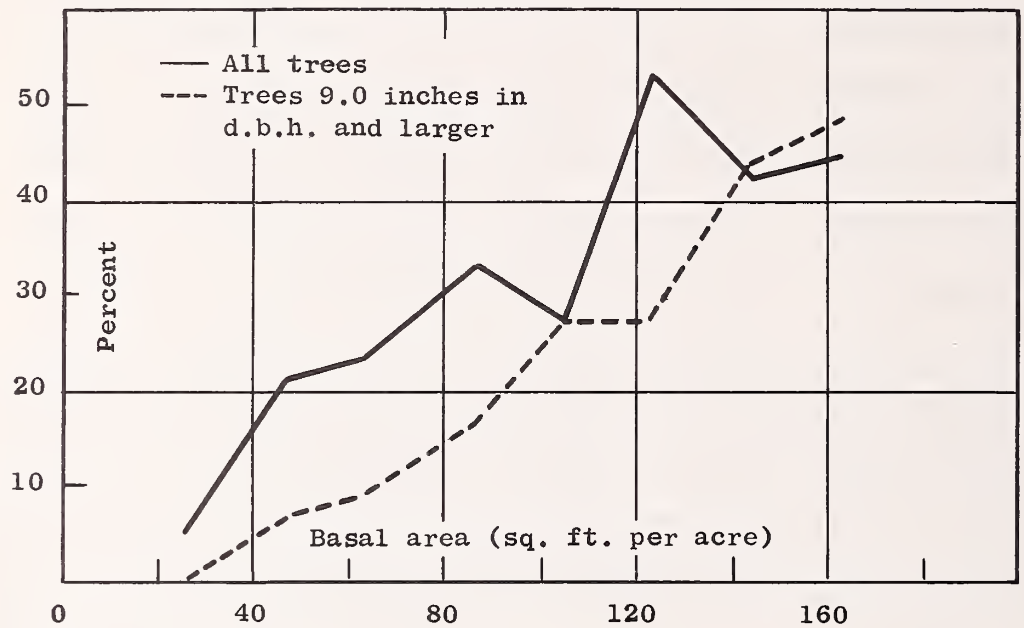

Figure 2.--Proportion of red pine trees classed as poles or as potential poles by stocking level.

The proportion of poles and potential poles increases with stand density but seldom exceeds 45 to 50 percent even in the very dense stands.

The proportion of acceptable pole trees is also affected by crown class. Dominant trees generally have larger crowns and heavier limbs, giving them a lower acceptance rate than that of the codominant and intermediate crown classes. When the pole acceptance rates for trees 9.0 inches and larger are plotted over basal area (fig. 2), the trend line is considerably lower than the trend line for all trees except in the densest stands. In very dense sawtimber stands, even the dominants have small crowns with few large limbs.

Wide spacing in plantations and early thinnings in natural and planted stands have been recommended to reduce snow damage. The results of this survey indicate that, while wide spacing will reduce the number of damaged trees, the reduction in the proportion of damaged trees will be slight and may be offset by increased limbiness (fig. 3).

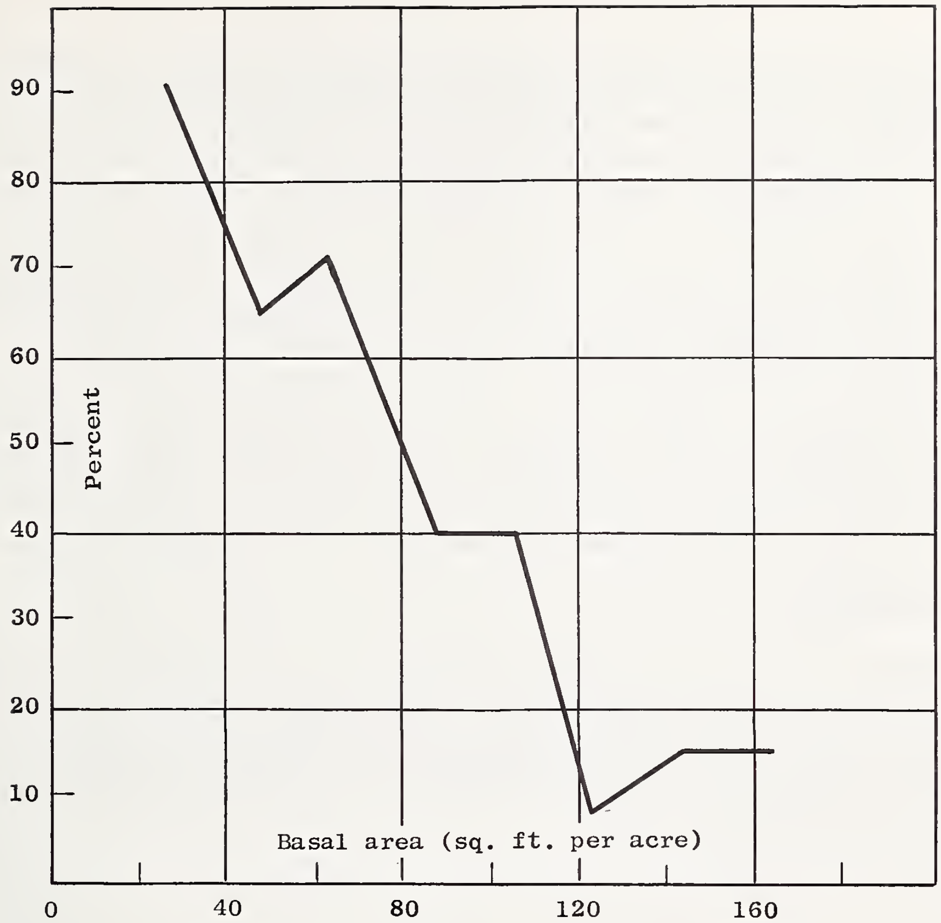

Figure 3.--Proportion of red pine trees rejected for limbiness by stocking level.

In the stands examined, the proportion of limby rejects increased rapidly in small sawtimber and poletimber stands whenever the basal area of all trees 5.0 inches and larger in diameter dropped below 120 square feet per acre. With reasonable survival on medium-to-good sites, red pine plantations spaced from 5x5 feet to 8x8 feet usually have a total basal area of 160 to 180 square feet per acre by age 30. The basal area in trees 5.0 inches and larger will usually range from 100 to 120 square feet per acre. At these spacings and at age 30 the lower limbs will be dead to a height of about 18 feet and the limbs between 20 and 40 feet will usually average less than 1.0 inch in diameter.

At wider spacings the height to live crown will be lower and many of the trees will be too limby long before they are large enough for poles. Even though the limbs may die out to a height of 40 feet or more, the large dead limbs will persist and cull the poles. A red pine plantation spaced 10x10 feet will not reach a total basal area of 120 square

feet per acre until the trees average over 7.0 inches in diameter. Nearly all of the dominants will be too limby for poles and about half of the codominants and intermediates will be culled for crook or sweep. Limbiness is more of a problem in plantations than in dense natural stands. The even spacing in a plantation allows even crown development on all sides of a tree, increasing the number of branches per whorl. The plantation grown trees usually average 4 to 6 branches per whorl; the trees in natural stands average only 3 to 4 branches per whorl. This difference appears to be fairly constant in stand densities ranging from 60 to 140 square feet of basal area per acre.

For maximum pole production, plantation spacing should not exceed 8x8 feet and thinnings normally should be deferred until the stands have a total basal area of about 160 square feet per acre. Stand density should not be reduced much below 140 square feet per acre until the limbs are dead to a height of 40 feet.

Sweep and Crook

In addition to those trees unacceptable for poles because of limbiness, a surprisingly high proportion was also rejected because of crook, sweep, or other defects. The proportion of trees rejected for causes other than limbiness did not decrease as stand density increased. In fact, the proportion rejected appeared to increase slightly as stand density increased (fig. 4).

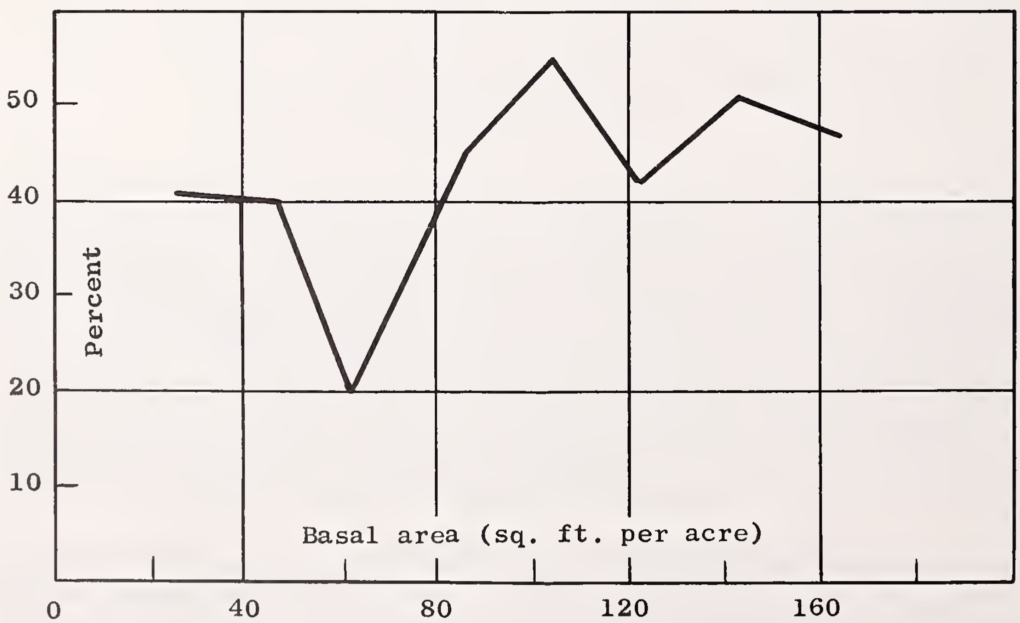

Figure 4.--Proportion of red pine trees rejected because of crook, sweep, and defects other than limbiness by stocking level.

Nearly all of these trees were rejected for crook or sweep, but a few had been struck by lightning, some had suffered recent wind or ice breakage, and a few showed logging damage. These other losses were small, seldom exceeding 5 percent of the trees examined, and all of the trees were still merchantable for pulpwood or sawlogs.

Sweep is a gradual bend in a pole; when the deviation exceeds more than 1 inch in 6 feet of length, it will cull the pole. The causes of sweep are difficult to identify and may often be a combination of factors. Some probable causes are wind, snow damage, or overhead shade, or sweep may be an inheritable characteristic. The random direction of the sweep found in any one stand tends to rule out wind as a major factor. In wind-damaged stands the trees are usually root sprung and the direction of the sweep is usually in one direction. Such stands generally have more than the usual number of trees with broken tops. The heavy wet snows occurring almost every year seldom break the tops but they do cause severe bending in young stands. Many of the trees straighten up in the spring; others may be left with enough sweep to cull them as poles.

Two types of simple sweep, convex and concave, were found in the red pine examined during the pole survey. Convex sweep is apparently the direct result of forces that bend the top of the tree toward the ground. This type of sweep would occur if the trunk did not spring back after being bent by ice or snow. However, most of the damaged trees exhibit concave sweep. This follows the height growth response to bending; it develops after a sapling is displaced from a vertical position and the subsequent growth of the terminal shoot turns back to the vertical. Some trees show compound sweep--convex sweep in the lower part of the bole (the direct result of bending) and concave sweep in the upper part of the bole (the height growth response to bending). Concave and compound sweep in pole-sized or larger trees can usually be traced back to bending damage that occurred when the trees were saplings less than 30 feet tall. Convex sweep in pole-sized or larger trees apparently is the result of bending damage when the tree was a slender intermediate, 3 or 4 inches in diameter and 30 to 40 feet tall.

The irreversible bending by snow or other causes, resulting in either type of sweep, seems to be confined largely to sapling-sized trees. Tree mortality does not appear to be higher among trees with sweep than among straight trees. Consequently, if trees 5.0 inches and larger developed sweep, they would constitute an increasing proportion of the trees in the stand. However, when the percentage of trees culled by sweep is plotted over tree diameter, the percentage does not change markedly with a change in diameter (fig. 5 on next page).

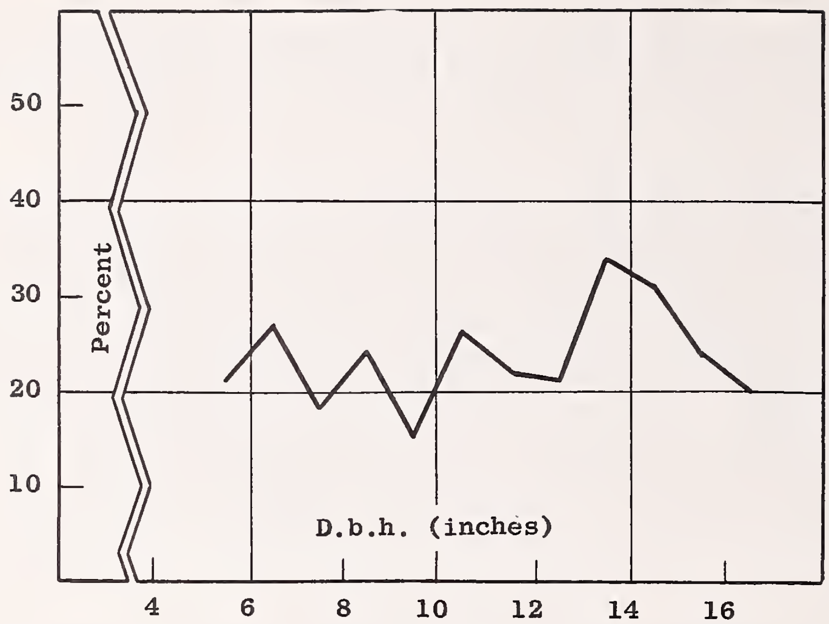

Figure 5.--Proportion of red pine trees rejected for sweep by diameter class.

During the winter of 1955-56 a number of plantations 5 to 20 years of age were examined for current snow bending that might result in permanent damage. In the younger plantations, 5 to 10 years old, the trees were still open grown and the lower limbs were still alive. Severe bending of the entire trunk was most pronounced in small spindly trees, particularly those with asymmetrical crowns. The larger trees carried heavier snow loads on their wide crowns but the bending was often confined to the last 2 years' terminal growth. This type of bending is not likely to result in permanent damage. However, any initial bending makes the tree more susceptible as additional snow falls during the same season.

In 15- to 20-year-old plantations some of the larger trees had branches torn out of the trunk by snow loads that did not necessarily bend the trunk. Bending of the entire trunk was more common in small trees, particularly those on the edges of natural openings caused by unfavorable soil conditions. Many of these small trees had asymmetrical crowns and were usually bent toward the center of the opening. Normal trees on the edges of chance openings--those caused by Christmas tree cuttings, animal damage, or plantation edges--showed less damage but were bent more frequently than trees in the interior of the stand.

A re-examination of these plantations in early April 1956 indicated that permanent bending damage is related to both the severity of the bending and the location of the bend. Whenever the bending was confined to the last 2 years of growth, nearly all of the trees had recovered. Apparently, permanent damage occurred only when severe bending extended down through the upper half of the crown.

While any red pine may be bent by heavy wet snows, bending is most severe in spindly trees and in any tree with an asymmetrical crown. Spindly trees may be found anywhere in a stand as a result of competition, past damage of any kind, adverse soil conditions, or shade from overtopping hardwoods. Trees with asymmetrical crowns are common on the edges of plantations, around openings caused by unfavorable site conditions, and openings in a hardwood overstory (fig. 6). Red pine plantations growing under hardwoods are particularly subject to snow damage since nearly all of the trees are spindly and many of them have asymmetrical crowns (fig. 7 on next page). Early release by cutting or removing the hardwoods with herbicides can minimize the damage.

A crook is an abrupt bend in the trunk of a tree that culls the tree for use as a pole. The development of a crook usually follows the loss of the leader from insect, wind, ice, or other damage. The crooks caused by insect damage are often absorbed, especially when the loss occurs above the first laterals. Wind and ice breakage normally comes at a point further down in the crown, and the already established laterals do not turn up sharply enough for the crook to be absorbed. Wind losses are infrequent, but when they do occur the wind often uproots the tree or breaks off the entire crown instead of merely breaking the leader. Damaging ice storms are also infrequent, but a single storm can ruin a stand for pole production. One 60-year-old stand examined during the pole survey had been hit by an ice storm in the 1920's; 75 percent of the red pine left in 1955 were culled for poles

Figure 6.--Red pine growing at the edge of an opening in a hardwood overstory have asymmetrical crowns and are often snow damaged.

Figure 7.--Red pine plantations under a hardwood overstory are particularly subject to snow damage.

because of severe crook. However, losses such as this are infrequent; the pole losses from crook are about half as large as those from sweep.

Crook caused by insects can be minimized by controlling insect populations with insecticides or by other control measures. Wind and ice breakage occurs infrequently but when either does occur, the action is so severe that damage-prevention measures through silvicultural management have little value.

Silvicultural Recommendations

Red pine is well adapted to intensive management and can yield a variety of valuable products. Within the silvicultural limits of its growth habits and permissible rotations, many variations of management aims are feasible depending upon the products to be grown. One such product is the red pine utility pole. The increase in red pine acreage through planting and release, the high pole potential of the older plantations, and possibility of realizing this potential through good silviculture all combine to make management for poles attractive.

In discussing management prescriptions, it should be clearly recognized that many red pine stands cannot be managed with utility poles as the primary product because of the low level of stocking or poor quality of the trees, although they may be satisfactory for sawlog production. Furthermore, many owners may have neither a market nor any interest in producing poles. The tentative recommendations presented here are for those owners in Lower Michigan interested in producing the maximum number of red pine trees that will meet the American Standard Wood Pole Specifications (see Appendix B). Even for these owners, and where conditions are favorable, poles will make up only part of the production, and much pulpwood and sawlog material will be produced.

To most observers there will be little apparent difference between a stand managed for utility poles and one where integrated product management has sawlogs for the primary product with some poles and piling to be cut in intermediate harvest cuts. Both poles and sawlogs require reasonably straight, thin-limbed trees, but the specifications for poles are much more stringent than those for sawlogs. Any tree usable for a pole will make a good sawlog, but according to this survey about half of the red pine in Lower Michigan that would be acceptable as a sawlog crop tree because of quality, vigor, and position in the stand would not meet the A.S.W.P. specifications for poles. In a tree selected as a sawlog crop tree, sweep and crook can be minimized by careful bucking. These defects or a few coarse limbs in the second log may be offset in sawtimber by better than average diameter growth and proper spacing in regard to adjacent crop trees. In a stand managed for pole production, such trees would be discriminated against in favor of smaller trees that are potentially usable as poles.

Spacing

In Lower Michigan nearly all of the well-stocked sapling stands of red pine are in plantations; most of the natural stands are too open to be considered for pole production. Plantations spaced 5x5 to 8x8 feet will usually produce an adequate number of straight, thin-limbed trees to make pole management feasible. Wider spacings will seldom do so.

Release

Plantations overtopped with poor hardwoods should be given a complete release as soon as possible. The overtopping hardwoods will reduce the growth of the red pine trees and make them very susceptible to snow damage. The hardwoods can be removed by cutting or controlled by aerial sprays or ground treatments with selective herbicides.

Early Thinnings

Early noncommercial thinnings in sapling-sized plantations are seldom necessary to maintain satisfactory growth rates, particularly in plantations spaced 6x6 feet or more. Usually thinnings can be deferred until the stands average 4 to 6 inches in diameter and have a total basal area in excess of 150 square feet per acre. In very dense natural stands or in plantations spaced closer than 5x5 feet, noncommercial thinnings may be needed to maintain the growth. However, thinnings in stands averaging 2 or 3 inches in diameter would be of questionable value in molding the stand for pole production. Permanent bending damage is difficult to assess until the trees are about 5 inches in diameter. Then too, trees 5 to 7 inches in diameter and 35 to 45 feet tall are relatively immune to further bending damage.

When very dense stands are encountered, they should be thinned to a spacing of about 5x5 or 6x6 feet to prevent loss of growth and to shorten the period before the first commercial thinning.

Commercial Thinnings

At age 25 to 35 years the first commercial thinning for pulpwood or fence posts can be confined largely to poor trees that will never be usable for poles. Regardless of the initial spacing or survival, about half or more of the trees will be too crooked for poles, and some of the largest trees will be too limby. Most of the poor trees to be cut will be slow-growing intermediates; some of the poor codominants and dominants will be left for later thinnings. Although the dominants--the largest and fastest growing trees--may often be too limby to be potential pole trees, only a few will be cut in the first thinning. These few are either too coarse limbed even for sawlogs or else they are adjacent to trees that are straight, thin-limbed, and apparently able to use the additional growing space without excessive limb development. This first thinning will increase the proportion of potential pole trees in the stand and remove trees that are or will be suppressing pole trees, but it will not encourage rapid diameter growth and crown spread of the residual trees. After thinning the stand should have a total basal area of about 140 square feet per acre. This stocking is light enough to allow for satisfactory growth without permitting excessive limb development.

Commercial thinnings may be made at 4- to 6-year intervals, removing 4 to 8 cords per acre from crooked and limby trees. A residual stocking of 140 square feet per acre should be maintained until the lower limbs are dead to a height of 35 to 40 feet. This amount of "dead length" will develop by age 55 to 65 years.

Improvement Cuttings

Once the boles are free of live limbs throughout the length of a utility pole, heavier cuttings can be made to remove many of the remaining crooked or limby trees and stimulate increased diameter growth on the pole trees. The stocking of the residual stand will be influenced by the total number of pole trees in the stand. Stockings of from 100 to 120 square feet of basal area will be low enough for satisfactory diameter growth of the pole trees. In Lower Michigan these stockings are high enough to prevent serious invasion by brush or hardwoods, but in other areas and on heavier soils higher stockings may be needed. Stocking levels of 100 to 120 square feet per acre can be maintained in Lower Michigan by cuttings at 5- to 10-year intervals until appreciable numbers of trees are of pole size.

Harvest Cuttings

At about age 80 years the rest of the poor trees will be removed along with those pole trees that are approaching the maximum diameter desired. Trees not usable as poles may be cut for sawlogs, or for piling if a piling market is available. Periodic harvest cuts can be made at 5- to 10-year intervals; these cuttings will be largely from above to maximize the number of usable poles that can be produced. As the stand nears maturity, the management prescriptions already worked out for red pine should be followed.[3/]

Summary

Red pine is one of the most productive timber types in Lower Michigan, and the type area has been greatly extended by forest planting. It is a versatile species and can yield a variety of valuable products. The red pine utility pole is a product with a large potential market.

A study was made in 1955 of the red pine stands of Lower Michigan to estimate the supply of trees suitable for utility poles and to evaluate the stand conditions that favor the development of red pine usable as poles. The present supply was estimated at about 215,000 trees that would meet the American Standard Wood Pole Specifications for class 4, 5, 6, or 7 poles. The potential supply in trees now between 5.0 and 9.5 inches in d.b.h. was estimated to be nearly 1.6 million trees. As the large acreage of plantations becomes merchantable, the future supply will be much greater.

The major pole defects are crook, sweep, and knots or limbiness. About half of the red pines examined were rejected because of crook or sweep. The proportion of trees rejected for crook and sweep was only slightly affected by stand density. The most serious cause of crook appeared to be ice damage to sapling- and small pole-sized stands. The losses from sweep are about twice as large as those caused by crook. The most important single cause of sweep is snow damage to sapling-sized trees. The proportion of trees rejected for limbiness is strongly correlated with stand density and increases rapidly as stand density drops below 120 square feet of basal area per acre.

3/ Eyre, F. H., and Zehngraff, Paul. Red pine management in Minnesota. U. S. Dept. Agr. Cir. 778, 70 pp., illus. 1948.

Since about half the trees in most stands have too much crook or sweep for a pole, the proportion usable for poles can be nearly doubled by careful selection of growing stock in thinnings and improvement cuttings. Limb size in the residual stand can be controlled by maintaining about 140 square feet of basal area per acre until the limbs are dead for the desired length of a pole. Once this point is reached, subsequent management will be the same as for a stand managed with sawlogs for the primary product.

APPENDIX A

Forest Survey Definitions

Forest Survey Stand Size and Stocking Classes

(net volume per acre)

Stocking class	Large sawtimber	Small sawtimber	Pole-timber
	Thousand board-feet International $\frac{1}{4}$-inch rule		Unpeeled cords
Well	10.0+	6.0+	13.0+
Medium	5.0- 9.9	3.0-5.9	7.0-12.9
Poor	1.5- 4.9	1.5-2.9	3.0- 6.9

Tree Classes

Sawtimber trees:

Softwoods--live trees 9.0 inches and larger in d.b.h., at least 40 percent sound, and with at least one 8-foot log. Minimum top d.i.b. (diameter inside bark) is 8 inches.

Hardwoods--live trees 11.0 inches and larger in d.b.h., at least 40 percent sound, and with at least one 8-foot log. Minimum top d.i.b. is 8 inches.

Poletimber trees:

Softwoods--live trees 5.0 to 8.9 inches d.b.h., at least 40 percent sound, and with at least one 8-foot bolt. Minimum top d.i.b. is 4 inches.

Hardwoods--live trees 5.0 to 10.9 inches d.b.h., at least 40 percent sound, and with at least one 8-foot bolt. Minimum top d.i.b. is 4 inches.

APPENDIX B

Utility Pole Specifications

Dimensions of Red Pine Poles[1]

Length of pole	Groundline distance from butt	Minimum d.i.b. at 6 feet from butt for poles of class--			
		4	5	6	7
Feet	Feet	Inches			
30	5½	10.9	9.2	8.6	8.0
35	6	10.7	9.9	9.1	8.4
40	6	11.3	10.5	9.7	8.9
45	6½	11.8	11.0	10.2	9.4
Minimum top d.i.b.--inches		6.7	6.0	5.4	4.8

1/ Adapted from table 4 (Dimensions of jack pine, lodgepole pine, red pine, and western fir poles (fiber stress 6600 pounds per square inch)) in American Standard Specifications and Dimensions for Wood Poles. American Standards Association, 1948.

Maximum limitations of knot sizes for poles 45 feet and under in length.

Diameter in inches of any single knot or knot cavity for:		Sum of diameters in inches of all knots and knot cavities for all classes:	
Classes 1-3	Classes 4-10	In any 1-foot section	In any 6-inch section
4	3	8	6

Shape

Poles shall be free from short crooks.

Where sweep is in one plane, a line from the surface at the groundline and the edge of the top will have a maximum distance from the surface of 1 inch for each 6 feet of length between these points.

Where sweep is in two planes or two directions, a line from the midpoint at the groundline to the midpoint of the top must lie within the pole.

SOME STATION PAPERS PUBLISHED IN 1957

The Market for Domestic Charcoal in Wisconsin, by John R. Warner and William B. Lord. Sta. Paper 46, 15 pp., illus.

Natural Regeneration on a 2-Acre Mixed-Oak Clear Cutting Five Years After Logging, by Harold F. Scholz and A. J. DeVriend. Sta. Paper 48, 11 pp., illus.

Deterioration of Sugar Maple Following Logging Damage, by Gene A. Hesterberg. Sta. Paper 51, 58 pp., illus.

A Record of the Timber Cut from Forests of the Lake States, 1954, by Arthur G. Horn. Sta. Paper 53, 47 pp., illus.

Marking Guides for Northern Hardwoods Under the Selection System, by Carl Arbogast, Jr. Sta. Paper 56, 20 pp., illus.

Silvical Characteristics of:

- Red Pine, by Paul O. Rudolf, Sta. Paper 44, 32 pp., illus.
- Black Spruce, by M. L. Heinselman. Sta. Paper 45, 30 pp., illus.
- Rock Elm, by Harold F. Scholz. Sta. Paper 47, 16 pp., illus.
- Quaking Aspen, by R. O. Strothmann and Z. A. Zasada. Sta. Paper 49, 26 pp., illus.
- Sugar Maple, by R. M. Godman. Sta. Paper 50, 24 pp., illus.
- Tamarack, by Eugene I. Roe. Sta. Paper 52, 22 pp., illus.
- American Elm, by Paul C. Guilkey. Sta. Paper 54, 19 pp., illus.
- White Spruce, by Hans Nienstaedt. Sta. Paper 55, 23 pp., illus.